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LABORATORY EXPERIMENTS ON ACOUSTIC PENETRATION INTO CONSOLIDATED SEDIMENTS

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High frequency acoustics

LONG TERM GOALS

To understand the relative roles played by interface roughness and sediment characteristics in determining the amount of energy that penetrates across water/sediment interfaces at "post-critical" angles. To use this understanding to delineate the most important parameters needed in predicting the potential for buried mine detection.

OBJECTIVES

Two hypotheses concerning penetration into sediments at shallow grazing angles will be tested. They are:

Porosity contributes significantly to "post-critical" penetration of acoustic energy (incident from water) into consolidated (i.e., non-zero frame rigidity) sediments.

Interface roughness contributes significantly to "post-critical" penetration of acoustic energy into consolidated sediments.

APPROACH

The experiments are being conducted in an evacuatable tank instrumented with precision positioning equipment for manipulation of transducers in the water column above either a homogeneous solid or a consolidated porous solid layer. The water/solid surfaces of the samples will initially be smooth and then roughened to a known profile by use of a computer controlled mill. The experiments to this point have concentrated on forward scattering from a smooth interface nonporous solid (plexiglas) and we are now preparing a rough interface on it. The acoustic properties of the plexiglas have been measured. The roughness of the interface will be small enough that the perturbation modeling can be used to predict the transmission of energy into the sediment due to surface roughness. The goal in the first sets of experiments is to experimentally test the predicted levels of penetration due to roughness for the case where the propagation equations are well known.

WORK COMPLETED

Perturbation theory for the bistatic scattering through a rough interface has incorporated into scattering code that calculates the intensity received due to roughness-caused transmission when a transmitter and hydrophone are placed above the interface such that post-critical penetration is dominate. The perturbation theory of this code (Thorsos et al) was used to simulate field and laboratory experiments examined by Chotiros.

RESULTS

The simulations using perturbation theory indicate that penetration due to surface roughness is a viable explanation for the results of both field and laboratory experiments to date. The simulations of the laboratory experiment being conducted show that there should be geometries where the contribution from sub-critical penetration can be isolated and measured.

IMPACT/APPLICATION

The identification of the mechanisms of sub-critical penetration are an essential first step to quantifying mine detection capabilities during naval operations in areas with sand bottoms.

TRANSITIONS

The perturbation theory and scattering code used in this project is part of a bistatic scattering model being used in the Coastal Systems Stations' SWAT simulation and imaging code for mine detection and classification efforts.

RELATED PROJECTS

The new Departmental Research Initiative on "High Frequency Sound Interaction in Ocean Sediments" aims to examine sub-critical penetration as part of a series of field experiments. The codes produced during the present research are being used to simulate the sensor configurations proposed for the field experiment. These simulations have allowed predictions of the levels expected and are now being used to examine the speed and angles of arrival ambiguity plots as a function of sensor geometry

REFERENCES

E. Thorsos, D.Jackson, J.Moe, K. Williams, “Modeling of sub critical penetration into sediments due to interface roughness,” Proceedings of the High Frequency Acoustics in Shallow Water Conference, Lerici, Italy July 1997.

N. P. Chotiros, "Biot model of sound propagation in water-saturated sand," *J. Acoust. Soc. Am.*, **97**, 199-214 (1995)